UDC 666.32

APPLICATION OF POLYMINERAL GZHEL' CLAYS IN CERAMICS PRODUCTION

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Translated from *Steklo i Keramika*, No. 1, pp. 32 – 33, January, 2009.

It has been established by means of investigations and commercial tests that clays from the Gzhel' deposit can be used to produce brick and facade and floor tiles as well as majolica, pottery, artistic and architectural articles, crafts, and other articles.

The Gzhel' clay deposit lies in the Meshchera lowlands. Here the ground is a flat, slightly undulating, divided plain with extensive marshy sections. The particularities of the bedding of the foundation rock determine the present-day relief.

Although these clays are now the main raw materials for the production of brick and tiles they have also been used for a long time in Gzhel' to make majolica articles. Moreover, according to K. K. Gal'perina [1] clays from the Gzhel' deposit were used in the mid-twentieth century to make tiles for the interior lining of walls and facades. The demand for raw materials in this form is increasing today, since it is used not only by enterprises within the Gzhel' region but also outside its borders.

The total reserves of low-melting clays for the production of brick according to the Gzhel' group of deposits were 5635 thousand m^3 on January 1, 1986.

These clays can be divided into three types according to their exterior appearance:

dark- and light-grey (Jurassic) clays of average thickness 0.37 m;

light-blue – greenish-grey sandy (anthracite coal) clays with average thickness 2.62 m;

red, brown, grey, green (variegated, anthracite coal) clays with average thickness 7.84 m.

Laboratory and factory tests performed on clays from the Gzhel' deposits have shown an elevated content of coarse-grain inclusions in them. The inside residue on a 0.5 mm sieve was 0.01 – 0.91 and 1.03 – 8,89% (upper and lower horizons).

These clays possess a comparatively uniform chemical composition and satisfactory moldability.

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Technological Properties of Clays

Molding moisture content, %	25 – 29
Shrinkage in air, %	7.90 – 9.75
Coefficient of sensitivity to drying (according to Nosova), %	1.12 – 1.50

The addition of 15 – 25% grog material to clay makes it possible to decrease the air shrinkage to 6.5 – 7.7%.

The freeze resistance coefficient corresponds to 0.65 – 0.96. The freeze resistance can also be improved by adding grog to the mix.

As a result of the investigations performed and commercial tests, Gzhel' clays have been accepted as being suitable for producing construction brick by plastic formation using grog materials. The 150 grade is recommended for solid brick. Hollow bricks can also be made from these clays.

Geological surveys performed in 1985 – 1986 determined the reserves of clays for the production of fine ceramics, i.e. for producing pottery and majolica articles by "Ob'edinenie Gzhel' " JSC.

The reserves of clays for producing majolica at one of the surveyed sections No. 1 in the town of Konyashino were 1227.6 thousand metric tons. Clay production was tested in layers. The clays encountered on this section are characterized by various texture and structure, diverse colors, different degrees of cluttering with large-grain inclusions, degree of thinning, and so on.

The most interesting with respect to the production of clays for majolica production is the section No. 2 near the town of Rechitsy. This section consists of two colored layers — variegated and red.

x-ray diffraction data show that Gzhel' clays contain quartz, hydromica, kaolinite, feldspar, calcite, montmorillonite, siderite, dolomite, chlorite, hematite, and goethite.

Comparing the granulometric compositions of the red and variegated clays shows that the content of the finely disperse particles smaller than 1 μm in variegated clay is much higher than in red clay and reaches 46%. The granulometric compositions of clays from section No. 2 (town of Rechitsy) of the Gzhel' deposit are presented in Table 1. The tests showed that the plasticity of the variegated clays is higher than that of red clays.

TABLE 1.

Clay	Fractional content, %, μm				
	> 63	10 – 63	5 – 10	1 – 5	< 1
Red (disperse)	3.47	37.63	11.93	19.05	27.92
Variegated (medium dispersity)	–	13.00	14.00	27.00	46.00

An investigation of clay samples obtained during the geological surveys of the Gzhel' deposit showed that the ceramic properties of the clays can be predicted from the color. For example, green, grey-green, grey, light-grey, dark-grey, and light blue clays have a more dense structure, high plasticity, fine dispersity (the content of fractions smaller than 1 μm reaches 42.4%), elevated fire shrinkage (4.4% at 1000°C), depressed porosity after annealing (7.0 – 10.7%) in contrast to the red, variegated, and red-brown clays.

All Gzhel' clays are low-melting.

Commercial tests established that Gzhel' clays from sections Nos. 1 and 2 can be used in ceramic pastes for the production of majolica articles.

Ceramic pastes based on one of the Gzhel' clays (the variegated clay) can lower porosity in the air-dry state from 12 to 7% provided that 40 or 70% of the same clay is added to the paste but only in the activated state, i.e., pre-milled. In the process the ceramic paste is densified. As Fig. 1 shows, the fraction of the finely dispersed particles after the clay is milled increases by almost 10%, which creates the possibility of decreasing the porosity in the air-dry state.

Densification of ceramic material was also accomplished in the course of the tests by mixing different types of clays in different combinations.

The investigations of the mechanical strength and porosity showed that of the samples with 10 different compositions of the majolica pastes containing three different types of clays — variegated, grey-green, and lilac colored clays in different ratios, the highest values of the strength 54.8 – 56.5 MPa were found for pastes containing 60 – 70% variegated and 20 – 30% lilac colored clays. The difference in the porosity was 11.2 – 13.5%.

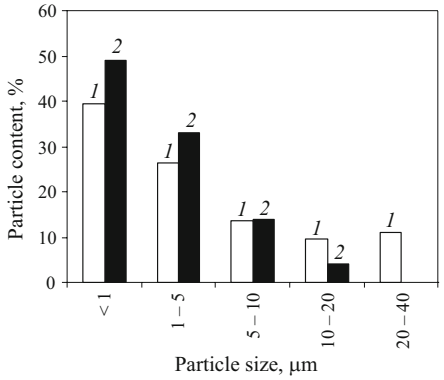

Fig. 1. Granulometric composition of variegated clay before (*1*) and after (*2*) milling.

The ceramic pastes developed on the basis of Gzhel' clays and various additives — nepheline syenite and glass cull — are characterized by lower porosity.

The sinterability of these pastes was determined at 1000°C with the ratio $RO : R_2O$ = 0.25 – 0.33 and $RO + R_2O$ = 14.6 – 20.0. It should be noted that replacing nepheline syenite with glass cullet (10 – 30%) in the charge shifts sintering onset in the direction of low temperatures (to 900°C). The pastes containing 40 and 50% glass cullet already sinter at 800°C; water absorption corresponds to 4.1 – 8.0%.

In summary, Gzhel' clays can be used successfully to produce ceramic building articles (brick, tiles, and so forth), pottery, majolica, artistic and architectural articles, crafts articles, and others.

REFERENCES

1. M. K. Gal'perina, *Clays of Russia for the Production of Ceramic Articles* [in Russian], Moscow (1992).